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Introduction to Using Native Plant Community on Dredge Material Placement Areas

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PURPOSE: This Engineering With Nature (EWN) Technical Note (TN) is the first in a series concerning the use of vegetation in Dredge Material Placement Areas (DMPA), including Confined Disposal Facilities (CDF), to achieve specific operational, engineering, and ecological benefits. Establishment of native plant communities within DMPA and CDF offers several advantages in terms of sustainability and cost. Once established, these communities will go through natural succession, possibly providing multiple services to include the following:

- providing wildlife habitat
- inhibiting invasive species establishment
- enhancing, structural stability of dikes
- providing shoreline stabilization
- accelerating sediment dewatering.

The overall goal of this vegetation on DMPA project is to develop resources and tools to inform the user of native plant communities, including wetland and terrestrial communities, the functional objectives, sediment properties, topography, and hydrology of disposal areas. While disposal area construction techniques are well documented, guidance pertaining to vegetative treatments and planting regimes to stabilize and promote ecosystem development on these placement areas is lacking. This TN will introduce relevant engineering and scientific concepts including background information; future EWN TNs and other publications in this series will further define how plants can be used in more specific applications. A web accessible tool will be developed identifying applicable plants in the coastal environment of the Atlantic and Gulf Coasts and in the Great Lakes region. The application and benefits of establishing and managing native plant communities on DMPA and CDF will be evaluated in the Atlantic and Gulf Coast and the Great Lake regions.

BACKGROUND: Currently, DMPA provide for temporary or permanent confinement of dredged material produced during dredging of navigable channels in waters of the United States, including bays, inland rivers, harbors, and berthing areas. Typically, a diked structure is constructed and then filled with dredged material over an extended period of time (i.e., 10–50 years) until the capacity is exhausted. Opportunistic invasive plant species tend to colonize DMPA/CDF during idle periods or following closure; these monocultures are not ecologically desirable, and most active DMPA/CDF must be managed to prevent excessive vegetation establishment that would possibly interfere with disposal operations. Native plant communities may be beneficial in preventing dike erosion resulting from wind and wave action on active

DMPA/CDF and are more cost effective to establish than other structural solutions, such as riprap. In some cases, plants may also reduce offsite transport of particles from the surface of the sediments placed in the disposal areas, creating the potential to accelerate dewatering and consolidation.

Following closure of a DMPA/CDF, active management is needed to establish and maintain native plant communities that offer ecological benefits for fauna and prevent the establishment of less-desirable species long term.

Native plantings offer other benefits. Environmental impacts associated with aggressive and undesirable vegetation management alternatives (i.e., herbicide application and mechanical removal), may be avoided. Further, with proper management the placement areas themselves (whether nearshore CDF or islands) may contribute to coastal resilience by providing protection from storm surge, adding structural integrity for living shorelines and contributing to ecological benefits such as wildlife habitat and linkage of greenways to sustain migratory fauna as they travel along the coastal and inland waterways.

PROBLEM AND OPPORTUNITY: Most CDF/DMPA have not undergone defined planting treatments. In some cases a monoculture of undesirable invasive plant species is the dominant plants growing on the sites, precluding establishment of a healthy, diverse, and appropriate native plant community. In addition to the ecological and operational objectives of strategic planting, it is important to take into account facility configuration, material characteristics of the dikes, and sediment placed hydrodynamics of the facility, location, climate and internal hydrology, and the type, frequency, and level of activity at the placement area. These factors will inform of both planting opportunities and needs while providing the most appropriate plant treatments, and species to achieve the integrated planting objectives. The intended end use of the site is also important (i.e., will it be transitioned from disposal to some other beneficial use). The planting environment existing at a disposal facility may vary considerably at different points on, or within the structure, including but not limited to these variables:

- slope and stability of the planting surface
- exposure to erosive wave action
- grain size, organic content and contaminant level of sediments placed in the facility
- water content of soil/sediment surfaces
- presence of rip rap
- other factors.

It is therefore very important to understand not only the construction of a disposal facility but also the operations taking place on the site with respect to disposal, site management, and material processing or recovery. On-site operations will vary throughout the life cycle of the facility, beginning with construction, possibly progressing through an expansion or material recovery phase, and ultimately closure of the site. In addition to these construction activities, there may be active dewatering and material reworking or recovery operations at different times. Therefore, the opportunities as well as the needs for stabilization and establishment of habitat will vary from site to site, from month to month, and from year to year. A planting strategy that integrates all operational considerations will be required in order to successfully utilize vegetation to achieve engineering and ecological objectives. For this reason, a general overview of typical disposal facilities and placement operations is included in this TN; on a site-specific basis, this will provide the context for development of a planting strategy.

The National Vegetation Classification (Grossman et al. 1998) is a scientific database of plant communities nationwide that will be used to determine which plant communities need to be planted at the two case study sites. By planting the appropriate native species, the vegetative communities will go into natural succession, which have self-repairing and self-sustaining capability. Succession progresses over time and space and is a dynamic ecological process; this concept aligns well with the U.S. Army Corps of Engineers (USACE) culture of sustainability and the goals of the EWN program (www.EgineeringWithNature.org) concerning grasses and herbaceous species. The plant community could then shift over time by planting additional species of shrubs and trees and/or allowing natural succession processes to occur as appropriate to the particular region. Through the use of biotechnical techniques, native plants also have potential for physical stabilization of CDF/DMPA structures. It is the intention of this TN to add environmental benefits by planting appropriate native plant communities in sync as the CDF/DMPA structures are filled and developed over their lifecycle.

CONSTRUCTION AND TYPES OF CONFINED DISPOSAL FACILITIES (CDF): Typically, CDF are constructed to contain dredged material when other disposal alternatives (i.e., open water or beneficial use) are not available or when the material is considered unsuitable for such placements. The characteristics of CDF vary according to the volume, frequency, and contaminant level of the material being dredged, the method of dredging and disposal, and other site-specific factors influencing the structure itself. The use of CDF for containment of dredged material originated in response to concerns regarding the impacts of open water disposal (Hammer and Blackburn 1977; Miller 1998). CDF were initially used primarily to contain dredged material considered unsuitable for open water disposal due to the presence of anthropogenic contaminants; over the ensuing years, open water disposal has become increasingly restricted, with the result that relatively clean materials were also placed in CDF rather than in open water. When disposal initially began to shift from open water to confined disposal, procedures for construction of containment facilities were not well established; some CDF consisted of dikes that were "haphazardly constructed and frequently breached" or they were constructed in natural depressions (Hammer and Blackburn 1977).

There are three major categories of CDF employed for the containment of navigation dredged material:

- Island
- Nearshore
- Upland.

As of 1998, 44 CDF had been constructed in the Great Lakes region. Approximately one-third consisted of upland CDF, and the remainder were in-water CDF. The size of the CDF in the Great Lakes region as of 1998 ranged from 3 acres up to 700 acres, with a design capacity ranging from 19.5K cy to 18M cy. Craney Island, in the Norfolk District, is a 2500-acre nearshore site. Almost all of these sites were designed with a planned future use after filling, including solid waste disposal, recreation, wildlife habitat, waterfront development, and an airport (Miller 1998).

Examples of each CDF type are shown in Figure 1.

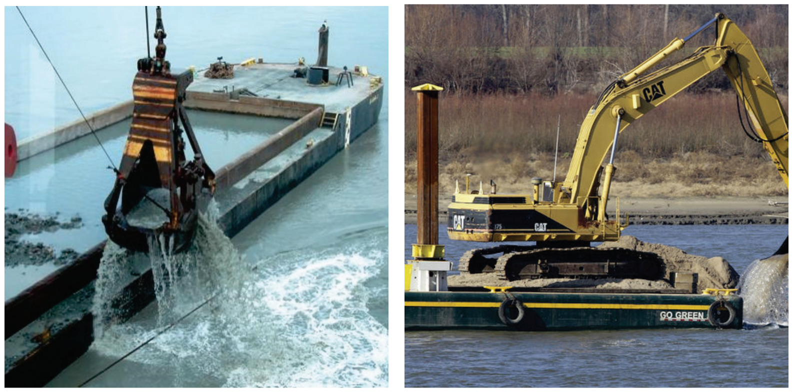
(a) (b) (c)

Figure 1. (a) Island CDF (USACE District, Detroit), (b) Nearshore CDF (Milwaukee, USACE District, Detroit), (c) Upland CDF (Indiana Harbor, USACE District, Chicago).

These CDFs share common functional objectives but may differ widely with respect to how they are constructed (i.e., other site features such as discharge structures and armoring). The primary function of all CDF is to contain the sediment solids produced by dredging; incidental to solids containment is the management of water produced in conjunction with dredging (effluent) and produced on the site by rainfall (runoff). The volume of water produced varies widely depending upon the construction design, dredging technique, and offloading methods used.

Mechanical dredging, which involves the removal of sediments from the navigation channel with some type of excavator, most often a clamshell or barge-mounted backhoe (Figure 2), entrains the least water during dredging (10% to 30% of the in situ sediment volume). Hydraulic dredging, which involves re-suspension of sediments into a slurry that is then pumped through a pipeline to a disposal area (Figure 3a), typically produces water volumes roughly four times that of the *in situ* volume of the sediment.

A sediment may be mechanically dredged and mechanically offloaded from barges, mechanically dredged and hydraulically offloaded, or hydraulically dredging and delivered directly to the disposal facility via pipeline. The distinctions are important operationally, influencing the size and type of CDF structure and appurtenances that are constructed, the condition of the dredged material immediately following placement in the disposal facility, and the physical and geochemical changes occurring in the condition of the dredged material over time. The manner of disposal also influences the segregation and distribution of different sediment grain sizes taking place during disposal. Hydraulic disposal results in deposition of coarse-grained materials near the discharge point, with progressively finer materials settling out along the flow path to the discharge structure. Mechanically dredged and offloaded sediment may be fluid enough to flow to some extent but not so fluid that separation occurs and the in situ grain size distribution of the material is not altered significantly as a result of the dredging and disposal process. These factors may be important when designing a vegetation management or re-vegetation plan for the interior of a disposal site.



(a) (b)

Figure 2. (a) Clamshell dredge. (b) Barge mounted backhoe excavator.

(a) (b)

Figure 3. (a) Pipeline disposal – hydraulic dredging or offloading. (b) Manitowoc CDF illustrates accumulation/placement of solids at one end of the facility and ponding at the opposite end. This is typical, especially at CDF where material has been placed hydraulically.

Figure 3 illustrates a typical in-water CDF where material has been placed or discharged near one end of the facility and water is allowed to flow and pond near the other end, facilitating the settlement of suspended solids prior to discharge to the surrounding water (receiving water).

There are three basic types of dike construction, with many variations and combinations of these (Hammer and Blackburn 1977):

- Hauled
- Cast
- Pumped.

The manner of placement as well as the character of the materials will determine the final distribution of material fractions in the dike and initial side slope of the dike. Once the material has dewatered, it can potentially be reworked to a more desirable configuration within the limitations imposed by the type of material. The finished dike slopes will vary considerably, depending upon the natural angle of repose of the material (e.g., coarser material is stable at a higher slope than fine material).

Hydraulically Placed Dikes. The initial slope of hydraulically placed dikes is heavily influenced by how well the placement is controlled and the geotechnical properties of the material. For new work in clay sediments, clay balls may form and separate out from the remainder of the slurry. The clay balls have a different angle of repose and load bearing capacity than the more diffuse material remaining in the slurry. Side slopes formed by clay balls may range from 1 on 7 to 1 on 25. By comparison, side slopes formed by coarse, angular materials ranges from 1 on 5 to 1 on 10. Dispersed fines remaining in a slurry may have a very low or no angle of repose and require a period of 2 to 3 years to develop a thick surface crust. A slope of 1 on 500 is fairly typical for hydraulically placed fine materials settling out within a CDF, assuming there is sufficient area to maintain full ponded depth near the weir. Hydraulically placed silty materials will also have a very low angle of repose and will dewater somewhat faster than clays, requiring perhaps 1 to 2 years to dewater sufficiently to be trafficable. Organic clays and silts are generally fully dispersed in slurry and are considered very low-strength materials that are undesirable for dike construction (Hammer and Blackburn 1977).

The design specification for dike slopes will depend not only upon the manner of construction and the material being used to construct the dikes but also the strength of the foundation materials and setback from the water's edge. An extended, low-slope dike may be required for a CDF constructed on poor soils, near the water's edge. Figure 4 is provided as an example.

The location of the CDF also influences construction materials and manner of placement. For example, most in-lake facilities have stone dikes constructed with layers of stone of increasing size. The center of the dike (core) typically contains sand or gravel. The outer layers of the dike have stone with sizes increasing from several pounds to several tons to protect the facility from wave energy. Most existing in-lake CDF do not contain liners; the stone dikes are permeable upon construction. The in-lake CDF has ponded water in hydrostatic equilibrium with the adjacent harbor, river, or lake (Miller 1998).

In-water CDF are generally constructed with stone-filled dikes that look and function much like a breakwater (Miller 1998). Figure 5 illustrates pipeline disposal taking place over the stone dike of the Chicago Area CDF. Material may be discharged at multiple points along the waterside of a CDF, thus influencing the final distribution of the material within the facility.

Upland disposal facilities are typically constructed with earthen dikes but may also use existing pits or depressions in the earth (Miller 1998). Dikes are frequently raised by excavating dredging material from within the CDF and placing it on top of the existing dike, usually stepping the dike inward from the original crest. Therefore, dike construction materials may vary considerably from site to site and even within a single site.

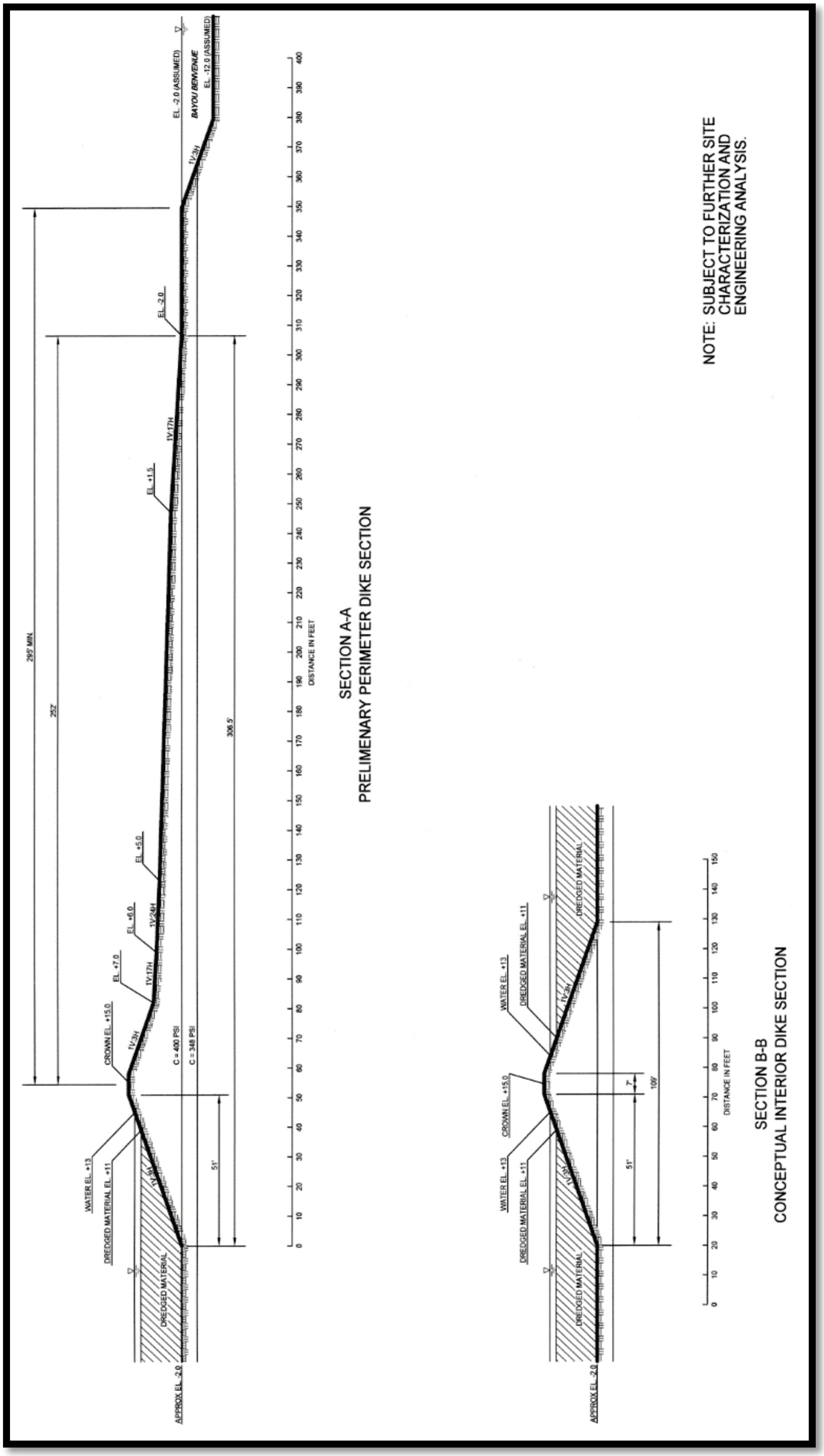


Figure 4. Profile section of dike.

Figure 5. Chicago area CDF stone dike and hydraulic (pipeline) discharge of dredged material into the CDF.

Upland CDF dikes are frequently constructed of native soils or dredged material (particularly in 2nd stage construction/expansion efforts), unless available borrow or dredged materials are of poor quality. While most CDF are not lined unless there are contaminant-related concerns with respect to the material to be dredged, neither are they highly permeable. Where the dredged material contains a significant percentage of fine materials, these may form a nearly impermeable layer in the bottom of the CDF.

Many CDF dike designs parallel that of flood protection levees or earth-filled dams with some significant differences (USACE 1983; Hammer and Blackburn 1977). The retaining dikes on a CDF must be able to withstand a ponded condition for extended periods of time and construction may take place on less than ideal foundation conditions (usually constructed with whatever materials are readily available).

A CDF will have a continuous external perimeter dike but may also have cross-dikes or spurs to compartmentalize the area or direct flow. If the site is divided, this may be to allow cycling of placement between the cells so that one cell can be dewatering while the other is actively receiving material. Alternatively, one cell may serve as a primary settling basin and a second cell as a secondary settling basin; in this case, there will typically be some form of conduit or weir connecting the cells allowing the flow of water from one to the other. From a post-closure perspective, these distinctions are primarily important because of the resulting segregation and distribution of sediment grain size materials in each cell. Where both cells receive dredged material directly from the dredge or barge, material should be comparable from cell to cell, unless there is great variation in the materials being dredged. Where the 2nd cell acts as a secondary settling basin, the contents of the cell will be predominantly fine materials, the coarse materials falling out of the slurry in the 1st cell.

Because dewatering is a key function of a CDF, there are possibly features remaining on closure that would have some impact on water retention and surface elevation within the site. Although not common, some sites may have an under-drainage system. More commonly, for sites that are actively managed during dewatering, a trench will be dug around the inner dike perimeter to encourage flow of water released from the sediment away from the bulk of the material and toward the outfall. With time and re-establishment of vegetation following closure, the distinctions between these structures, depending upon their initial size, can become difficult to see. The original construction specifications for the dike and site maintenance records may be the best sources of information on the construction materials used in the dikes, for purposes of determining planting compatibility.

Where more contaminated material is to be placed in a CDF, a clay or geotextile fabric liner may be required; in some cases a clay "key" is constructed along the centerline of the dike to prevent transmission of water through the dikes as well. These are not commonly required measures for navigation dredged material, but the possibility should be considered where it is relevant to placement of transition or where biotechnical plantings is placed to stabilize the dikes so that the root systems do not penetrate these barriers and provide for a pathway for release of contaminated leachate or surface waters. Further, the potential for contaminant uptake by plants and trophic transfer of contaminants up the food chain must be considered. Where contaminant types and concentrations are such that biouptake and trophic transfer is a significant concern, establishment of habitat and encouraging use of the site by wildlife may not be environmentally sound.

EXISTING DATABASES FOR DMPA AND CDF

National Placement Data Manager. The National Placement Data Manager (NPDM) is a database currently under development for the purposes of tracking and projecting the volumes and placement areas used for disposal of dredge material by navigation dredging projects throughout USACE. The NPDM is "disposal-centric," in that data entry is tied to individual disposal sites. Therefore, projections can be made regarding remaining useful life, need for future capital improvements or replacements, and budgeting priorities can be made on a programmatic level. The database will also provide analysis and tools useful in site management planning on an operational level; the degree and type of vegetation management is one piece of information that will be collected in this database. At the time of this report, the site was undergoing beta testing, preparatory to being released USACE wide.

National Dredging Quality Management Program. The National Dredging Quality Management (DQM) Program is the USACE's automated dredging monitoring system. It utilizes analysis tools and the National Placement Database as a server providing information on active dredging operations nationwide (Hammer and Blackburn 1977). The program's mission is to provide USACE dredging managers with a standardized, low-cost, remote monitoring and documentation system. Used to track all dredging work, this system is highly effective in providing the USACE with timely data access in multiple reporting formats with full technical support including dredge certifications, data quality control, database management, and support for the DQM operating system. On board the dredge, sensors continually monitor dredge activities, operations, and efficiency. Information from these sensors is routed to the National DQM Support Center for data processing, storage, and publishing (USACE 2012).

The DQM web-based tools can be utilized to view project operations and produce disposal plots and data for export of dredge operations. The DQM operating system is widely used by contractors, USACE operation managers, and other stakeholders. Additional benefits of the DQM include the following:

- Monitors and documents where and when dredging and disposal operations take place
- 24/7 coverage of operations
- Reduces paperwork
- Creates detailed production reports
- Allows for fast responses to public or environmental concerns
- Allows for flexible scheduling of human inspectors
- Improves government estimates and planning
- Improves project management
- Standardizes data collection and reporting
- Creates a standard base for dispute resolution and avoidance.

The DQM program is efficient in capturing data related to dredging operations to include name of channel, time of dredging, amount of dredged material, time of placement, and quantity placed. However, this information is different than what is available within the National Placement Data Manager.

National Placement Database. This data base (http://dqm.usace.army.mil) provides access to data on dredge disposal placement areas and active placement areas. The DQM data were obtained from the USACE Mobile District for the provided Corps of Engineers Districts (Table 1).

Table 1. Corps Districts that have available placement area data in the National Placement Database.

Alaska	Baltimore	Buffalo	Charleston
Chicago	Detroit	Galveston	Hawaii
Huntington	Jacksonville	Los Angles	Mobile
New England	New Orleans	New York	Norfolk
Philadelphia	Pittsburg	Portland	Saint Paul
San Francisco	Savannah	Seattle	Wilmington

The DQM Program is a USACE/dredging industry partnership for the automated dredging monitoring of USACE dredging projects. The Mobile District obtains the data as Map Services. A map service is a protocol for providing data from Global Information Systems (GIS) databases and other sources to mobile and web clients. The DQM database is more than just a geographic dataset; it is a combination of data and parameters for defining and delivering a dynamic, interactive, intelligent dredging database.

NATIVE PLANT COMMUNITIES: Native plants are critical resources for wildlife habitat, erosion control, sediment filtration, and water quality improvements and are the basic component of ecosystem restoration. Plants are often "keystone" species that hold together entire ecosystems and are important for many ecological processes to occur. Plant communities in the built environment can provide structure, function, and natural processes to create a sustainable landscape (Bailey 2014). The approach is a shift in emphasis, away from a fixed design held at a static moment, to a dynamic changing design allowing for plant communities to grow and mature over time. Plant communities not only survive but are adaptable to changing environmental conditions. Native plant communities have in-built natural resilience by genetic and species diversity. Incorporating native plant communities at dredged material disposal facilities will provide self-sustaining features in the landscape, requiring less maintenance than customary vegetation management alternatives, may prevent establishment of less desirable, invasive species, and will provide greater ecological benefits to the environment.

Existing National Vegetation Classification (NVC). The National Vegetation Classification (NVC) is a system used by many Federal agencies, including the USACE for its Level I and Level II survey efforts (Grossman et al. 1998). This same system can be used for more detailed botanical inventories to provide consistency and realize efficiency (and therefore cost effectiveness). The USACE can use the NVC data as a guide for planting appropriate plant communities on DMPA and CDF nationwide, with increased survivability and long-term sustainability of the native plant communities, as they are adapted to the environment in which they occur naturally. This data is scientifically defensible based upon NVC inventories and Heritage Program Databases (Grossman et al. 1998).

NVC Data Used with Geographic Information Systems (GIS) Spatial Analysis. Vegetation data from four regional Gap Analysis Projects and the LANDFIRE project *www.Landfire.gov* were combined to construct this dataset that contains the NVC. These datasets were developed by the United States Geological Survey (USGS), EROS Data Center, Multi-Resolution Land Characteristics Consortium, and downloaded from the National Gap Analysis Program (GAP) Land Cover Data Portal (http://gapanalysis.usgs.gov). The most detailed classifications have been cross-walked to the five highest levels of the NVC: class, subclass, formation, division, and macro-group. The datasets can be displayed and analyzed at different levels of thematic resolution. Developed areas, or areas dominated by introduced species, timber harvest, or water are represented by other classes and are collectively referred to as land use classes. These land use classes occur at each of the thematic levels. Six layer files are included in the download packages to assist the user in displaying the data at each of the thematic levels in ArcGIS. Vegetation classes were drawn from NatureServe's Ecological System Classification (Comer et al. 2003) or classes developed by the Hawaii GAP project. Additionally, all of the projects included land use classes that were employed to describe areas where natural vegetation has been altered. In many areas of the country, these classes were derived from the National Land Cover Dataset (NLCD). For the majority of classes and in most areas of the country, a decision tree classifier was used to designate ecological system types.

Excel Table as a Tool. Selected NVC plant community data has been entered into an Excel table that will be available as a searchable database on the EWN website. This information can be used to inform decisions on what to plant on a proposed site and can be imported into geospatial data/mapping, therefore becomes a stand-alone tool.

Sources of Seed Mixes and Plant Material. Several sources of suitable plant materials include the U.S. Department of Agriculture (USDA) Plant Material Centers, the Extension

Service, and private native seed companies/ nurseries. On-site collection of seeds and plants may be possible on USACE properties. Additionally, the collection of plants used for biotechnical treatments from on-site sources will often be best because the material can be harvested at the right time and properly stored until it is planted, without having the complications of contracting for this at the proper time, and it is adapted to local conditions.

GOALS AND APPROACH OF THIS WORK UNIT: The goal of this program is to provide guidance for establishing appropriate native plant communities that are effective, low cost solutions to stabilize CDF/DMPA. First, a series of publications including this TN will be produced for USACE Districts use to aid in selecting appropriate plants for DMPAs/CDFs in marine or freshwater ecosystems and to compile a list of suitable species for all strata to include herbaceous plants, shrubs, and trees (using NVC data) in the focus areas. The areas chosen to demonstrate applicability of the approach are the Gulf Coast and the Great Lakes regions. This guidance is a template on how to plant CDF/DMPA for any project. This includes 1) access to the NVC plant data in an easy to use excel table; 2) phased CDF/DMPA construction scenarios with integrated plant treatments will be described. Purposes of plant treatments include dewatering, dust control, bank stabilization of the CDF/DMPA structure, and in some cases, establishment of desirable habitat; 3) creation of generic specifications and guidelines to develop construction guidance for site preparation and planting; and 4) additional resources (bibliography) will be listed. This design guidance will be electronically available through the EWN website and a hardcopy downloaded from an active link on the EWN webpage.

Two USACE Districts (Galveston and Buffalo) have been selected as partners for the workshops. Workshops conducted will become case studies. Other case studies could be added in later years under further program directives or as reimbursable projects.

CONCLUSION: This TN provides the introduction, purpose, and primary goals of the project as well as the possibility of future efforts. Additional reference sections including native plants that are appropriate for coastal saline environments and biotechnical treatments will be available in TN 2. Another publication will provide information on construction phasing in sync with appropriate native plantings strategies and the last publication will emphasize the chosen case studies describing the workshops (to be held at the Galveston District in 2017 and the Buffalo District in 2018).

ADDITIONAL INFORMATION: This technical note was prepared by Pamela Bailey, Research Botanist and Landscape Architect; Tosin Sekoni, Research Ecologist; Trudy Estes, Research Civil Engineer; Scott Bourne, Research Physical Scientist; and David Price, Research Plant Ecologist, Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center (ERDC). The study was conducted as an activity of the Engineering With Nature Initiative. For more information, please consult *www.EngineeringWithNature.org* or contact the Program Managers, Dr. Todd Bridges and Dr. Burton Suedel, at *Todd.S.Bridges@usace.army.mil* and *Cynthia.J.Banks@usace.army.mil*.

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